TechData Sheet

Naval Facilities Engineering Service Center
Port Hueneme, California 93043-4370

TDS-2031-E&U October 1996

Desiccant Systems Save Money

Desiccant systems can save the Navy money through lower utility bills. Traditional vapor compression air conditioning systems are required to remove both sensible heat and latent heat (humidity) by cooling the outside air below the dewpoint in order to condense out water vapor. In some cases the air is then required to be reheated to a comfortable level. This requires large amounts of electricity at peak billing rates. Desiccant systems, on the other hand, use a desiccant to remove moisture from the outside air prior to cooling the air using traditional chillers. The desiccant is then reactivated using natural gas heat. This will shift up to 40 percent of the cooling load of the building to natural gas which in many areas of the country is cheaper than electricity, especially during the peak hours in the summer. It also eliminates inefficient reheating and in most cases the temperature of the building can be raised since dry air is more comfortable at higher temperatures than humid air. Many buildings also require special humidity control which is most effectively and efficiently met using a desiccant system. These buildings include hospitals, commissaries, avionics rooms, BOQ's and BEQ's, etc.

How Desiccant Systems Work

The main component of the desiccant system is the desiccant. This can either be a solid usually a silica gel, or a liquid solution such as lithium chloride, which is sprayed into the airstream. Since the majority of desiccant systems being built today use solid desiccants, this Techdata Sheet will primarily address those systems.

Figure 1 shows the basic solid desiccant component - the wheel. The desiccant material is impregnated into a support structure. This looks like a honeycomb, which is open on both ends. Air passes through the honeycomb passages, giving up moisture to the desiccant contained in the walls of the honeycomb cells. The desiccant structure is formed into the shape of a wheel. The wheel constantly rotates through two separate airstreams. The first airstream, called the process air takes outside air, or recirculated air or a combination and passes it over the desiccant that dries the air and supplies it to the building space.

The second airstream, called the regeneration or reactivation air, takes outside air or air from the buildings and heats it. This air then passes through the desiccant wheel that has absorbed moisture from the process air and reactivates the desiccant. This resulting warm moist air is then rejected to the outside. Most desiccant systems have additional components to increase the efficiency of the desiccant and to remove sensible heat. Figure 2 shows a heat exchanger, either a thermal wheel or a heat pipe which removes sensible heat from the warm process air and transfers it to the cooler regeneration air. Most systems also install either cooling coils or a direct evaporative cooler downstream of the heat exchanger to further cool the process air. Many systems also include an indirect evaporative cooler in the reactivation airstream before the heat exchanger to cool the reactivation air so that the heat exchanger is more efficient.

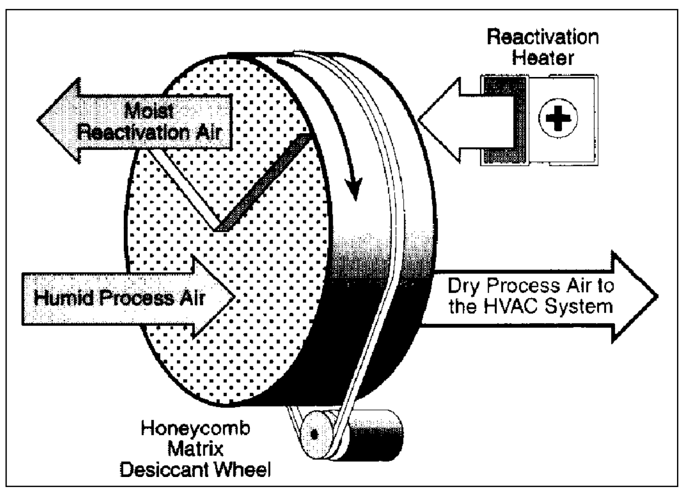

Figure 1. Desiccant wheel operating principles.
(Used by permission: The American Gas Cooling Center.)

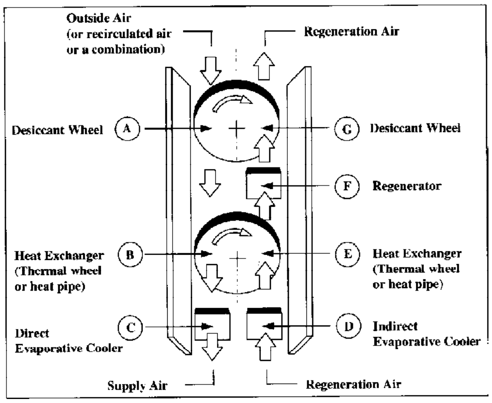

Figure 2. Desiccant dehumidification and evaporative cooling.
(Used by permission: The American Gas Cooling Center.)

Where Are Desiccant Systems Appropriate?

Every building is unique with respect to latent and sensible heat loads, local utility costs, humidity requirements, etc. Whenever a building's HVAC system is to be upgraded, whether to increase ventilation, provide better humidity control, or because the heat load has increased; or when new construction is planned, six factors should be looked at to determine whether or not a more in-depth study of a desiccant system for that building is warranted.

1. High Cost of Electricity Compared to Gas. In areas where the cost of electricity is high compared to gas, desiccant systems can realize large savings in utility bills. Since up to 40 percent of the cooling load on a building is latent heat, if this is shifted to gas during the peak demand hours in the summer when electrical rates are high and gas rates are low significant savings can result. As a rule of thumb, if summertime gas rates are less than $0.60 per therm and/or the electrical demand charge is over $9.00/kW, a desiccant system should be considered for a building.

2. Low Sensible Heat Load and High Latent Heat Load. In buildings with a high latent heat load compared to the sensible heat load it makes sense to use a desiccant system rather than a vapor compression system, which is less efficient and may only be used part of the year. In some cases when vapor compression systems are used to remove latent heat, the air must then be reheated to a comfortable dry bulb temperature.

Some examples of buildings with a high latent to sensible heat load would be a commissary or a movie theater or auditorium. With a commissary there is often a low sensible heat load due to the cool air spilling out of the frozen and refrigerated display cases. Often times the air must be heated year round to maintain a comfortable temperature in the aisles. Due to the latent heat load, however, frost continually forms on display case cooling coils and frozen foods. In a movie theater or auditorium the people are mostly sedentary, adding little sensible heat to the building. Also there is usually no other machinery or equipment in the building adding to the sensible heat load and in the case of movie theaters they are mostly utilized at night when there is little sensible load. Each person, however, constantly breathes in and out adding large amounts of water vapor to the air and consequently adding to the latent heat load. An easy way to determine if the sensible heat load to the latent heat load is low enough to consider a desiccant system perform the following calculation. (Heat load calculations are beyond the scope of this Techdata Sheet. For an explanation of how to calculate loads, see the 1993 ASHRAE Handbook, Fundamentals, Chapter 26.)

$$\frac{\text{Sensible Heat Load (Btu/hr)}}{\text{Sensible Heat Load (Btu/hr)} + \text{Latent Heat Load (Btu/hr)}} = \text{Sensible Heat Ratio (SHR)}$$

If the SHR is 0.8 or greater, the building may or may not benefit from a desiccant system. If the SHR is 0.7 or less, a desiccant system should definitely be considered for the building.

3. Required Dew Point. Some buildings require a low dew point which is better met by desiccant systems rather than inefficient vapor compression units. Two examples of buildings which require low humidity are commissaries and buildings where sensitive electronic equipment is calibrated or repaired. As the required dew point falls, desiccant systems become more efficient and vapor compression becomes less efficient. As a rule of thumb, when the required dewpoint is less than 50°F (55gr/lb) a desiccant system should be considered.

4. Outside Air as a Percent of Supply Air. Due to new ventilation requirements, new buildings and buildings undergoing major HVAC changes require more outside airflow than in the past, up to 20 cfm per person. Conventional air conditioning starts to have problems maintaining adequate cooling when outside airflow increases to 15 percent of the total supply air. When outside airflow is 20 percent or greater, conventional air conditioning will regularly fail to maintain the temperature of the building. A desiccant system can be used to treat most of the fresh air while conventional units treat less than 10 percent outside air thus keeping the building comfortably cool. As a rule of thumb, when the outside airflow is above 15 percent of total air flow, a desiccant system should be considered.

5. Need for Dry Duct Work. Fungus and bacteria are present in all indoor environments. In wet ducts and drip pans they may grow rapidly. In some buildings this may not matter, the building may just have a permanent musty odor. Other buildings may exhibit "sick building syndrome," with occupants having frequent upper respiratory infections, headaches, etc. The consequences of airborne microbes in some buildings such as hospitals may be severe. Although no thumb rule exists to determine whether or not an economic incentive exists for dry duct work, each building should be examined to determine what the consequences of airborne molds and fungi may be.

*6. **Exhaust Air Availability.*** If the exhaust air from the building can be returned to the desiccant unit to cool the process air via a thermal wheel or heat pipe before it is heated and used as regeneration air the efficiency of the desiccant system is greatly increased. The rule of thumb is that if the design already calls for return air ducting, desiccant systems and vapor compression are equal. If as a result of having return air the units can be downsized to lower initial installation costs then desiccant systems are favored. If return air is not available then vapor compression is favored.

Summary

Figure 3 shows a graphic representation of the six factors explained above. As each of the six factors are evaluated, they should be plotted on Figure 3. Figure 3 should then be evaluated to determine whether or not a desiccant system should be considered for a particular building. As Figure 3 shows, the more points that fall to the left of the graph, the more a desiccant system is favored. If at least two points fall on the left side of the graph, then a desiccant system should be considered. Individual building managers will have to decide how much to weight each factor. A hospital, for example, may consider dry duct work to be a primary factor and even though all the other factors may be on the right side of the graph, the hospital may still want to install a desiccant system.

The above factors should be a preliminary evaluation of the suitability of a desiccant system and should not be used for a final design decision. For further information, contact ***Paul Kistler*** at the Naval Facilities Engineering Service Center, Code 21, DSN: 551-1387, (805) 982-1387, Internet: pkistler@nfesc.navy.mil.

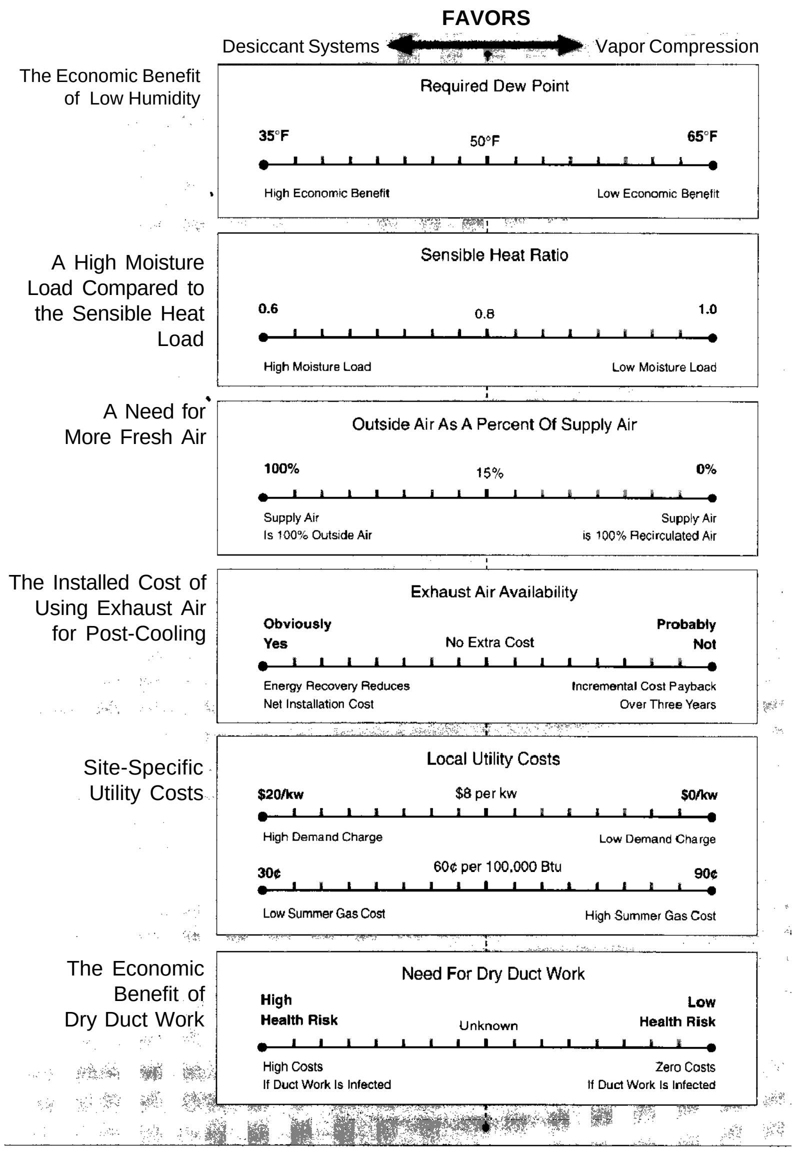

Figure 3. Graphic evaluation template for desiccant applications.
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